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(54) Title: GAS SPRING PISTON AS WELL AS GAS SPRING ASSEMBLY AND SUSPENSION SYSTEM INCLUDING SAME

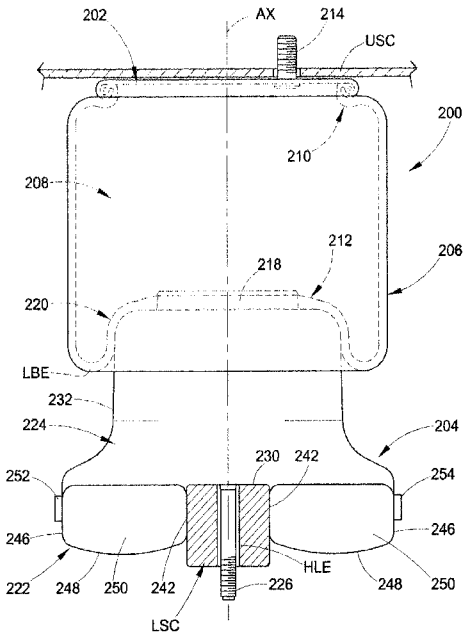


FIG. 3

(57) Abstract: A gas spring piston (204) is dimensioned to receive an associated flexible wall (206) and includes a side wall (232) that extends peripherally about a longitudinally- extending axis such that an associated rolling lobe of the associated flexible wall can be formed there along. The side wall at least partially defines a piston storage chamber capable of storing for an extended period of time a quantity of gas having a pressure level greater than an associated ambient atmospheric pressure. A passage extends through the side wall and into fluid communication with the piston storage chamber. A connector fitting (252, 254) is secured along the passage and is dimensioned to receive an associate gas transfer line for transferring pressurized gas into and out of the piston storage chamber. A gas spring assembly and a suspension system are also included.

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GAS SPRING PISTON AS WELL AS GAS SPRING ASSEMBLY AND SUSPENSION SYSTEM INCLUDING SAME

BACKGROUND

[0001] The subject matter of the present disclosure broadly relates to the art of gas spring devices and, more particularly, to a gas spring piston that includes a storage reservoir integrated thereinto that is capable of storing a quantity of pressurized gas. A gas spring assembly including such a piston and a suspension system including one or more of such gas spring assemblies are also disclosed.

[0002] The subject matter of the present disclosure may find particular application and use in conjunction with suspension systems of wheeled vehicles, and may be described herein with specific reference thereto. However, it is to be appreciated that the subject matter of the present disclosure is also amenable to use in a wide variety of other applications and environments, and that the specific uses shown and described herein are merely exemplary. For example, the subject matter of the present disclosure could be used in connection with gas spring assemblies of support structures, height adjusting systems and/or actuators associated with industrial machinery, components thereof and/or other such equipment.

[0003] Gas suspension systems, such as for use on vehicles, for example, are known to provide the capability of adjusting the height and/or alignment (e.g., leveling) of a sprung mass (e.g., a body or chassis of a vehicle) relative to an unsprung mass thereof (e.g., a wheel-engaging member or axle housing of the vehicle). As such, known gas suspension systems commonly transfer pressurized gas into and out of gas spring assemblies that are operatively connected between the sprung and unsprung masses. In this manner, the gas suspension system can alter or otherwise adjust the height and/or alignment of the sprung mass relative to the unsprung mass.

[0004] In conventional suspension systems, pressurized gas is routinely transferred out of one or more gas spring assemblies to thereby reduce the height of the same and achieve a desired leveling or height adjustment action, such as for leveling or lowering a vehicle body or chassis, for example. Normally, the pressurized gas that is transferred out of the one or more gas spring assemblies is

simply discharged into the external atmosphere, such as the ambient atmosphere surrounding the vehicle, for example. Recognizing that ambient atmospheric pressure is within a range of from approximately 12 psi to approximately 15 psi, depending upon elevation and other factors, the discharge of a quantity of gas having a pressure of approximately 60 psi or greater into the external atmosphere represents an uncontrolled release or loss of potential energy. From the perspective of efficiency and energy conversion, such regular and ongoing releases of stored energy may be deemed undesirable.

[0005] Additionally, in conventional suspension systems, air is regularly drawn in from the external atmosphere and compressed, such as by using an electrically operated compressor, for example, to a desired pressure level. This air can then be transferred into one or more gas spring assemblies, such as to increase the height of the same, or can be stored in a suitable reservoir or tank for use at a later time. In addition to the undesirable nature of wasting potential energy by simply discharging pressurized gas into an external atmosphere, such as has been described above, conventional suspension systems generate pressurized gas for use in the gas spring assemblies by taking in and subsequently pressurizing gas at nominal atmospheric pressure. Such a course of operation can result in significant energy consumption associated with the generation of pressurized gas.

[0006] In view of the foregoing, it is believed desirable to develop a gas spring piston, as well as a gas spring assembly and suspension including the same, that is capable of assisting in the reduction of the discharge of pressurized gas into an external atmosphere and/or otherwise providing improved performance of gas suspension systems.

BRIEF SUMMARY

[0007] One example of a gas spring piston in accordance with the subject matter of the present disclosure and dimensioned for receiving an associated flexible wall can include a side wall extending peripherally about a longitudinally-extending axis such that an associated rolling lobe of the associated flexible wall can be formed therealong. The side wall can at least partially define a piston storage chamber that

is capable of storing for an extended period of time a quantity of gas having a pressure level greater than an associated ambient atmospheric pressure. A piston passage can extend through the side wall and into fluid communication with the piston storage chamber. A connector fitting can be secured along the piston passage and can be dimensioned to receive an associated gas transfer line for transferring pressurized gas into and out of the piston storage chamber.

[0008] One example of a gas spring assembly in accordance with the subject matter of the present disclosure can include a flexible wall having a longitudinal axis and extending peripherally about the longitudinal axis between a first end and a second end that is spaced longitudinally from the first end. An end member can be secured across the first end such that a substantially fluid-tight seal is formed therebetween. A gas spring piston can be operatively connected to the second end of the flexible wall such that a spring chamber is at least partially defined by the flexible wall between the end member and the gas spring piston. The gas spring piston can include a side wall that extends peripherally about a longitudinally-extending axis such that a rolling lobe can be formed therealong by the flexible wall. The side wall can at least partially define a piston storage chamber that is capable of storing for an extended period of time a quantity of gas having a pressure level greater than an associated ambient atmospheric pressure. The piston storage chamber being fluidically isolated by the gas spring piston from the spring chamber. A piston passage can extend through the side wall and into fluid communication with the piston storage chamber. A connector fitting can be secured along the piston passage and can be dimensioned to receive an associated gas transfer line for transferring pressurized gas into and out of the piston storage chamber.

[0009] One example of a suspension system in accordance with the subject matter of the present disclosure can include a pressurized gas source and a control device that can be selectively operated in a plurality of flow control conditions. The suspension system also includes at least one gas spring assembly, such as has been described in the foregoing paragraph. The control device can be fluidically connected between the pressurized gas source and the at least one gas spring assembly. In a first flow control condition of the control device, the pressurized gas

source and the spring chamber of the at least one gas spring assembly are disposed in fluid communication with one another. In a second flow control condition of the control device, the pressurized gas source is fluidically isolated from the spring chamber with the spring chamber and the piston storage chamber disposed in fluid communication with one another. In this manner, pressurized gas can be transferred between the spring chamber and the piston storage device. In some cases, a third flow control condition of the control device can be provided in which the pressurized gas source, the spring chamber and the piston storage chamber are disposed in fluid communication with one another. In this manner, pressurized gas can be transferred from the pressurized gas source and the piston storage chamber into the spring chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a schematic representation of one example of a vehicle including a suspension system and gas spring assemblies in accordance with the subject matter of the present disclosure.

[0011] FIG. 2 is a side view of one example of a gas spring assembly in accordance with the subject matter of the present disclosure prior to installation on an associated structural component.

[0012] FIG. 3 is an end view of the exemplary gas spring assembly in FIG. 2 shown installed on the associated structural component.

[0013] FIG. 4 is a bottom perspective view of the exemplary gas spring piston shown in FIGS. 2 and 3.

[0014] FIG. 5 is a bottom plan view of the exemplary gas spring piston shown in FIGS. 2-4.

[0015] FIG. 6 is a cross-sectional side view of the exemplary gas spring piston shown in FIGS. 2-5 taken from along line 6-6 in FIG. 2.

[0016] FIG. 7 is a schematic representation of one example of a control device included in the suspension system shown in FIG. 1.

DETAILED DESCRIPTION

[0017] Turning now to the drawings, wherein the showings are for the purpose of illustrating examples of the subject matter of the present disclosure and which are not intended as a limitation of the same, FIG. 1 illustrates one example of a suspension system **100** disposed between a sprung mass, such as an associated vehicle body **BDY**, for example, and an unsprung mass, such as an associated wheel **WHL** or an associated wheel-engaging member or axle, for example, of an associated vehicle **VHC**. It will be appreciated that any such suspension system can include any number of one or more systems, components and/or devices and that the same can be operatively connected between the sprung and unsprung masses of the associated vehicle in any suitable manner. For example, such a suspension system can include a plurality of damping members (not shown), which can be operatively connected between the sprung and unsprung masses of the associated vehicle in any suitable manner.

[0018] Additionally, or in the alternative, such a suspension system can include a plurality of gas spring assemblies that are supported between the sprung and unsprung masses of associated vehicle **VHC**. In the embodiment shown in FIG. 1, suspension system **100** includes six gas spring assemblies, one or more of which is disposed toward each corner of the associated vehicle adjacent a corresponding wheel **WHL** thereof. It will be appreciated, however, that any other suitable number of gas spring assemblies could alternately be used and/or that such gas spring assemblies can be disposed in any other suitable configuration and/or arrangement. In the exemplary arrangement schematically represented in FIG. 1, a plurality of gas spring assemblies **102** are operatively connected between the sprung and unsprung masses of the vehicle with two of gas spring assemblies **102** operatively associated with front wheel-engaging members **104** of vehicle **VHC** and the remaining gas spring assemblies operatively associated with rear wheel-engaging members **106** of vehicle **VHC**. In particular, rear wheel-engaging members **106** are shown as including trailing arms **108** operatively connected thereto with gas spring assemblies **102** operatively disposed between a trailing arm and the sprung mass (e.g., body

BDY) of the vehicle. It will be appreciated, however, that other suitable arrangements and/or configurations could alternately be used.

[0019] Suspension system **100** can also optionally include a pressurized gas system **110** that is operatively associated with the gas spring assemblies for selectively supplying pressurized gas (e.g., air) thereto and selectively transferring pressurized gas therefrom. In the exemplary embodiment shown in FIG. 1, pressurized gas system **110** includes a pressurized gas source, such as a compressor **112**, for example, for generating pressurized air or other gases. The pressurized gas system can also include any number of one or more control devices of any suitable type, kind and/or construction that may be capable of affecting the selective transfer of pressurized gas. For example, a valve assembly **114** is shown as being in communication with compressor **112** and can be of any suitable configuration or arrangement. In the exemplary embodiment shown, valve assembly **114** includes a valve block **116** with a plurality of valves **118** supported thereon. Valve assembly **114** can also optionally include a suitable exhaust, such as a muffler **120**, for example, for venting pressurized gas from the system. Optionally, pressurized gas system **110** can also include a reservoir **122** in fluid communication with valve assembly **114** and suitable for storing pressurized gas.

[0020] The one or more control devices, such as valve assembly **114**, for example, can be in communication with gas spring assemblies **102** in any suitable manner, such as, for example, through suitable gas transfer lines **124**. As such, pressurized gas can be selectively transmitted to and/or from the gas springs through valve assembly **114**, such as to alter or maintain vehicle height at one or more corners of the vehicle, for example.

[0021] Suspension system **100** also includes a control system **126** that is capable of communication with any one or more other systems and/or components (not shown) of suspension system **100** and/or of vehicle **VHC**, and is capable of selective operation and control of the suspension system. Control system **126** includes a controller or electronic control unit (ECU) **128** in communication with one or more components of pressurized gas system **110** (e.g., compressor **112** and/or valve assembly **114**), such as through a suitable conductor or lead **130**, for example, for

selective operation and control thereof, including supplying and exhausting pressurized fluid to and from any number of one or more gas spring assemblies, such as gas spring assemblies **102**, for example. Additionally, it will be appreciated that controller **128** can be of any suitable type, kind and/or configuration.

[0022] Control system **126** can also optionally include one or more height or distance sensing devices (not shown) as well as any other desired systems and/or components. Such height sensors, if provided, are preferably capable of generating or otherwise outputting a signal having a relation to a height or distance, such as between spaced components of the vehicle, for example. It will be appreciated that any such optional height sensors or any other distance-determining devices, if provided, can be of any suitable type, kind, construction and/or configuration, such as mechanical linkage sensors, ultrasonic wave sensors or electromagnetic wave sensors, such as may respectively operate using ultrasonic or electromagnetic waves, for example.

[0023] Having described an example of a suspension system (e.g., suspension system **100**) that can include a gas spring assembly in accordance with the subject matter of the present disclosure, one example of such a gas spring assembly will now be described in connection with FIGS. 2 and 3. As shown therein, a gas spring assembly **200**, such as may be suitable for use as a gas spring assembly **102** in FIG. 1, for example, is shown as including an end member, such as top or bead plate **202**, for example, and an end member, such as gas spring piston **204**, for example, that is spaced from the other end member such that a longitudinal axis **AX** is at least partially formed therebetween. A flexible wall, such as a flexible sleeve **206**, for example, is secured between the end members (e.g., bead plate **202** and piston **204**) and at least partially forms a spring chamber **208** therebetween. Flexible sleeve **206** includes an upper mounting bead **210** and a lower mounting bead **212** formed along opposing ends the flexible sleeve.

[0024] Upper mounting bead **210** of flexible sleeve **206** is captured by the peripheral edge (not numbered) of bead plate **202**. It will be appreciated that the peripheral edge can be deformed around the upper mounting bead in any manner suitable for forming a substantially fluid-tight seal therewith. One or more

securement devices, such as mounting studs **214**, for example, can be included along bead plate **202**. In the exemplary embodiment shown in FIG. 2, mounting studs **214** project outwardly from the bead plate **202** and are secured thereon in a suitable manner, such as, for example, by way of a flowed-material joint or a press-fit connection. Such one or more securement devices may be suitable for securing bead plate **202** on an associated structural member, such as an upper structural component **USC** of a vehicle, for example, in any suitable manner, such as by way of one or more threaded nuts or other securement devices (not shown), for example. A fluid communication port, such as a fluid passage **216**, for example, can optionally be provided to permit fluid communication with a spring chamber **208**. In the exemplary embodiment shown, fluid passage **216** extends through at least one of studs **214** and is in fluid communication with spring chamber **208**. However, it will be appreciated that any other suitable fluid communication arrangement could alternately be used.

[0025] Although not illustrated in FIG. 2, the lower mounting bead of the flexible sleeve could be captured between an end closure and the piston assembly in a conventional manner, and the end closure could be secured on the piston assembly using a suitable securement device or assembly, such as a mounting stud and nut, for example. Alternately, piston **204** can include a bead mounting wall **218** that is adapted to receive and retain lower mounting bead **212**, such as is shown in FIGS. 2 and 3, for example.

[0026] With reference, now, to FIGS. 2-6, gas spring piston **204** is shown as extending generally longitudinally between opposing ends **220** and **222**, and including a piston body **224** as well as a securement feature, device and/or component provided on or along the piston body for securement of the gas spring piston on or along an associated structural member. In the exemplary arrangement shown in FIGS. 2-6, the securement feature, device and/or component takes the form of a threaded mounting stud **226** that is operatively connected to the piston body and projects longitudinally-outwardly therefrom in a direction away from end **220**. The associated structural member (e.g., wheel-engaging members **104**, wheel-engaging members **106** and/or trailing arms **108**) is represented in FIGS. 2 and 3 by

lower structural component **LSC**, which is shown as including a hole **HLE** that is dimensioned for threaded mounting stud **226** to pass therethrough and receive a suitable securement device or component, such as a threaded nut (not shown), for example. Of course, other fastening arrangements could alternately be employed.

[0027] A gas spring piston in accordance with the subject matter of the present disclosure, such as gas spring piston **204**, for example, includes at least one storage chamber or reservoir integrated into the piston body that is capable of receiving and storing a quantity of pressurized gas for an extended period of time, such as hours, days, weeks or months. In a preferred arrangement, the pressurized gas can be stored for such an extended period of time without a substantial reduction in the pressure level. In some cases, a loss of less than 50 percent of the gas pressure level may be acceptable. In other cases, however, a gas pressure loss of less than 25 percent and, more preferably, of less than 10 percent is preferred.

[0028] It will be recognized that gas spring pistons find specific application and use in association with the formation of gas spring assemblies that include at least one spring chamber, such as spring chamber **208** of gas spring assembly **200**, for example. Conventional gas spring assemblies are known to include gas spring pistons that at least partially define an additional volume or reservoir within the piston body. It is believed, however, that such additional volumes of known constructions are either placed in fluid communication with the spring chamber of the gas spring assembly or, alternately, fluidically isolated from the spring chamber but left in fluid communication with an external or ambient atmosphere. In either case, the additional volume within a piston body of known gas spring assemblies is not believed to be used as a storage chamber or reservoir that is capable of storing a quantity of pressurized gas that is substantially fluidically isolated from the pressurize gas within the spring chamber of the corresponding gas spring assembly, such as is the case with the subject gas spring piston.

[0029] It will be appreciated that gas spring pistons of a wide variety of shape, sizes and configurations have been developed and that the specific configuration illustrated herein is merely exemplary. As shown in FIGS. 2-6, gas spring piston **204** includes a piston storage chamber or reservoir **228** (FIG. 6) that is substantially

fluidically isolated from the spring chamber of the corresponding gas spring assembly (e.g., spring chamber **208** of gas spring assembly **200**). In the exemplary arrangement shown in FIGS. 2-6, gas spring piston **204** includes a bottom or base wall **230** that is dimensioned to abuttingly engage a side or surface of an associate structural member, such as lower structural component **LSC**, for example. In this regard, base wall **230** can at least partially define a mounting plane (not identified) of the gas spring piston that is disposed transverse to longitudinal axis **AX**. Gas spring piston **204** is also shown as including a first or outer side wall **232** that extends generally longitudinally between ends **220** and **222**. In use as a component of gas spring assembly **200**, a portion of flexible sleeve **206** forms a rolling-lobe **LBE** that is displaced along outer side wall **232** as the gas spring assembly undergoes changes in overall height, such as, for example, may be due to variations in load conditions applied thereto, as is well understood by those of skill in the art. It will be recognized that a wide variety of shapes, profiles and/or configurations can and have been used in forming the first or outer side wall of gas spring pistons. As such, it will be appreciated that the profile of first side wall **232** is merely exemplary.

[0030] It will be appreciated that storage chamber or reservoir **228** can be formed within gas spring piston **204** in any manner suitable for substantially fluidically isolating the storage reservoir from the spring chamber of a corresponding gas spring assembly (e.g., gas spring assembly **200**). For example, an end wall could extend substantially fully across end **220** of gas spring piston **204** such that a substantially closed end of the gas spring piston is formed thereby. Recognizing, however, that certain performance benefits can be realized through the use of a spring chamber having an increased size, it may be desirable to utilize a portion of the volume within the gas spring piston to increase the total volume of the spring chamber while also maintaining a fluidically-isolated reservoir within the gas spring piston. As one example of such a construction, gas spring piston **204** can include a second or inner side wall **234** that at least partially defines a piston cavity **236** having an opening **238** along end **220** such that the piston cavity can fluidically communication with an associated spring chamber, as shown in FIG. 6. Second or inner side wall **234** is shown as extending generally longitudinally between an end

portion **240** of outer side wall **232** and base wall **230** and thereby at least partially defines storage reservoir **228**, which remains fluidically isolated from piston cavity **236** and, thus, spring chamber **208**.

[0031] It will recognized and appreciated that embodiments of the present disclosure provide a gas spring assembly having a gas spring piston with an integrated storage reservoir can include or otherwise utilize an increased storage chamber volume as compared to known gas spring piston constructions. Such increased volume is achieved at least in part by locating a portion of the storage chamber volume below a mounting surface of the gas spring piston, such as, for example, in void space that is adjacent to a structural member along which the gas spring piston is to be mounted. As such, a wide variety of shapes, sized and/or configurations can be envisioned to accommodate the great number of applications and/or environments in which a gas spring piston in accordance with the subject matter of the present disclosure can be used. As will be appreciated, the void space available adjacent a structural member of a given vehicle will vary from vehicle to vehicle. Thus, aspects of the subject matter of the present disclosure can be broadly employed in designing gas spring pistons to utilize such unused space for increasing the volume of the storage chamber. For example, a method of making a gas spring assembly in accordance with the exemplary embodiments of the invention could include detecting or otherwise determining the presence, size and/or shape of void space adjacent a support member of a vehicle, and constructing a gas spring piston having a storage chamber that is dimensioned or otherwise adapted to occupy at least a portion of the detected void space.

[0032] Gas spring assemblies **102** and gas spring assembly **200** are illustrated as including at least a portion of the storage chamber that extends or is otherwise disposed below the mounting surface of the gas spring piston (e.g., base wall **230** of gas spring piston **204**). In the exemplary construction shown in FIGS. 2-6, gas spring piston **204** includes a pair of opposing and laterally spaced-apart inboard side walls **242** that extend longitudinally outwardly from along base wall **230** in a direction opposite end **220**. Side walls **242** at least partially define a channel or passage **244** along at least a portion of the gas spring piston that is dimensioned to receive and/or

engage at least a portion of an associated structural member, such as lower structural component **LSC**, for example.

[0033] Gas spring piston **204** is also shown as including a pair of outboard side walls **246**, as well as bottom walls **248** that are disposed in longitudinally-spaced relation to base wall **230** and each operatively interconnect one of inboard side walls **242** with one of outboard side walls **246**. Gas spring piston **204** can also, optionally, include opposing end walls **250** that are disposed in spaced relation to one another with side walls **242**, side walls **246** and bottom walls **248** extending therebetween. It will be appreciated that storage chamber **228**, as shown and described herein, represents a substantially contiguous volume having portions **228A** (FIG. 6) and **228B** (FIG. 6) that are disposed in spaced relation to one another on opposing sides of lower structural component **LSC** (e.g., in a pontoon-like configuration).

[0034] As described above, storage chamber **228** is at least substantially, if not completely, fluidically isolated from piston cavity **236**, if provided, and from spring chamber **208** of gas spring assembly **200**. As such, at least one fluid passage is preferably provided in fluid communication with storage chamber **228** such that pressurized gas transfer into and out of the storage chamber can be achieved. In this manner, storage chamber **228** can act as a fixed-volume reservoir for housing a quantity of pressurized gas separate and apart from the quantity of pressurized gas within the spring chamber of the gas spring. In the exemplary arrangement shown in FIGS. 2-6, connector fittings **252** and **254** are provided along outboard side walls **246** and respectively define passages **256** and **258**. In other arrangements, however, a single fitting and a corresponding passage could be used. In still other arrangements, one or more fittings and corresponding passages can be provided on or along a single, common wall, such as, for example, is illustrated in gas spring assemblies **102** in FIG. 1.

[0035] An integrated storage chamber or reservoir, such as storage chamber **228**, for example, is adapted to receive and store for reuse quantities of gas that have been pressurized for use in a gas spring suspension system. For example, storage chamber **228** could be used to receive and store pressurized gas that has been vented from or otherwise transferred out of a gas spring assembly. In some

cases, such a quantity of pressurized gas may be transferred out of the same gas spring assembly that includes the integrated storage chamber. In other cases, the pressurized gas stored in the integrated storage chamber may be from another source, such as a different gas spring assembly or a gas transfer line, for example. In a preferred arrangement, the stored quantity of gas can be retained at a pressure level above ambient atmospheric pressure, such as at a pressure level at least 10 pounds per square inch (psi) above ambient atmospheric pressure. In a more preferred arrangement, the stored quantity of gas can be retained at a pressure level at least 25 psi above ambient atmospheric pressure.

[0036] It will be appreciated that pressurized gas can be selectively transferred into and out of the integrated storage chamber in any suitable manner and in connection with the use of any suitable arrangement and/or configuration of components. As one example, FIG. 6 includes schematic illustrations of gas transfer lines (e.g., pressurized gas hoses) **260** and **262** that are operatively connected to connector fittings **252** and **254**, and in fluid communication with passages **256** and **258**, respectively. In the exemplary arrangement shown in FIG. 6, gas transfer line **260** can transfer pressurized gas into storage chamber **228**, such as to store pressurized gas from a dump cycle or leveling action, for example, as is represented by reference arrow **IN**. Gas transfer line **262** can transfer pressurized gas out of storage chamber **228**, as is represented in FIG. 6 by reference arrow **OUT**, such as to recycle the pressurized gas to the pressurized gas system (e.g., pressurized gas system **110** in FIG. 1) or directly into the corresponding gas spring assembly (e.g., gas spring assembly **200**). A suitable fluid passage, such as passage **216**, for example, could be used to transfer pressurized gas out of the spring chamber for storage in storage reservoir **228** and/or to transfer pressurized gas out of the storage reservoir and into the spring chamber of the gas spring assembly. One or more control devices, such as valves **264** and **266**, for example, can be optionally included to selectively control the transfer of pressurized gas into and/or out of integrated storage reservoir **228**. Such one or more control devices, if included, can be operatively controlled in any suitable manner, such as by ECU **128** of control system **126** in FIG. 1, for example, by way of conductors or leads **268** and **270**.

[0037] As another example, FIG 7 includes a schematic illustration of one example of a control device **132**, such as may be operatively associated with one or more gas spring assemblies, such as is shown in FIG. 1, for example. A plurality of the control devices are shown in FIG. 1 with each control device operatively connected between one of gas transfer lines **124** and one of gas spring assemblies **102** such that pressurized gas can be selectively transferred into and/or out of the spring chamber of one or more of the gas spring assemblies and such that pressurized gas can be separately and/or simultaneously transferred into and/or out of a storage chamber (e.g., storage chamber **228**) of one or more of the gas spring assemblies.

[0038] As is identified in FIG. 7, gas transfer lines **124** are operatively connected with control device **132**. A first transfer passage, such as is established by gas transfer line **134**, for example, extends between control device **132** and the spring chamber of a gas spring assembly (e.g., spring chamber **208** of gas spring assembly **200**). A second transfer passage, such as is established by gas transfer line **260** (FIG. 6) and/or gas transfer line **136** (FIG. 7), for example, extends between control device **132** and the piston storage chamber of a gas spring assembly (e.g., storage chamber **228** of gas spring assembly **200**). Additionally, a third transfer passage, such as is established by gas transfer line **262** (FIG. 6) and/or gas transfer line **138** (FIG. 7), for example, can, optionally, extend between control device **132** and the piston storage chamber of a gas spring assembly (e.g., storage chamber **228** of gas spring assembly **200**).

[0039] Control devices **132** can be selectively operated in any suitable manner. As one example, control devices **132** can be communicatively coupled with ECU **128** of control system **126**, such as by way of conductors or leads **140**, for example. It will be appreciated that the one or more control devices (e.g., control devices **132**) can include one or more actuators, springs and/or other components for selectively operating the control devices. As one example, control devices **132** can include one or more return springs **142** and/or one or more actuators **144**. In the exemplary arrangement show, actuators **144** can be communicatively coupled with ECU **128** and/or other systems, such as by way of conductors or leads **140**, for example.

Additionally, it will be appreciated that control devices **132** can be configured for operation in any suitable manner. On example of a suitable arrangement is shown in FIG. 7 as including a multi-position (e.g., three-position) valve assembly that is selectively operable or otherwise variable between a plurality of flow conditions.

[0040] In a first flow condition, which is schematically represented in FIG. 7 by arrangement **FC1**, gas transfer lines **124** and **134** are placed in fluid communication with one another such that pressurized gas can be transferred into and/or out of the spring chamber (e.g., spring chamber **208**). Additionally, in flow condition **FC1**, gas transfer lines **136** and **138** are shown as being fluidically isolated by the control device such that pressurized gas within the storage chamber (e.g., storage chamber **228**) is retained within the storage chamber at a first pressurized gas level above ambient atmospheric pressure.

[0041] In a second flow condition, which is schematically represented in FIG. 7 by arrangement **FC2**, gas transfer lines **124** and **138** are shown as being fluidically isolated. However, gas transfer lines **134** and **136** are placed in fluid communication with one another such that pressurized gas can be transferred between the spring chamber (e.g., spring chamber **208**) and the piston storage chamber (e.g., storage chamber **228**). In the arrangement shown, pressurized gas is being transferred out of the spring chamber and into the piston storage chamber, as is represented in FIG. 7 by arrow **146**. In this manner, the volume of the gas spring assembly can be reduced, such as to reduce the ride height thereof, for example, without venting the evacuated pressurized gas to an external atmosphere. Rather, the evacuated pressurized gas is stored within the piston storage chamber for later use.

[0042] In a third flow condition, which is optional and is schematically represented in FIG. 7 by arrangement **FC3**, gas transfer line **136** is shown as being fluidically isolated. However, gas transfer lines **124** and **134** are shown as being placed in fluid communication with one another, such that pressurized gas can be transferred into the spring chamber (e.g., spring chamber **208**), as is represented in FIG. 7 by arrow **148**. Additionally, flow condition **FC3** is shown with gas transfer line **138** disposed in fluid communication with gas transfer lines **124** and **134**, as is represented in FIG. 7 by arrow **150**, such that pressurized gas can flow out of the

piston storage chamber (e.g., storage chamber **228**) and be transferred into the spring chamber (e.g., spring chamber **208**).

[0043] It will be appreciated, however, that other flow conditions and/or arrangements of fluid connections could additionally, or alternately, be used. For example, in some cases, flow condition **FC3** could include gas transfer line **136** disposed in fluid communication with gas transfer lines **124** and **134**, as is represented in FIG. 7 by arrow **152**. In such case, pressurized gas could flow out of the piston storage chamber (e.g., storage chamber **228**) and be transferred into the spring chamber (e.g., spring chamber **208**), as discussed above. However, in such case, connector fitting **254**, passage **258**, gas transfer line **262** (FIG. 6) and/or gas transfer line **138** (FIG. 7) could be omitted and, thus, are optional.

[0044] It will be appreciated that the gas spring assemblies of the present disclosure can be operatively connected between the sprung and unsprung masses of an associated vehicle in any suitable manner. For example, as shown in FIG. 1 the gas spring assemblies can be operatively connected between wheel-engaging members and a body of a vehicle **VHC**. It will be appreciated, however, that the configuration of vehicle **VHC** in FIG. 1 is merely a schematic representation of the structural components of the sprung and unsprung masses of the vehicle. Thus, it will be understood that this schematic representation is provided for purposes of discussion and ease of understanding and is not intended to be in any way limiting.

[0045] As used herein with reference to certain features, elements, components and/or structures, numerical ordinals (e.g., first, second, third, fourth, etc.) may be used to denote different singles of a plurality or otherwise identify certain features, elements, components and/or structures, and do not imply any order or sequence unless specifically defined by the claim language. Additionally, the terms "transverse," and the like, are to be broadly interpreted. As such, the terms "transverse," and the like, can include a wide range of relative angular orientations that include, but are not limited to, an approximately perpendicular angular orientation. Also, the terms "circumferential," "circumferentially," and the like, are to be broadly interpreted and can include, but are not limited to circular shapes and/or

configurations. In this regard, the terms “circumferential,” “circumferentially,” and the like, can be synonymous with terms such as “peripheral,” “peripherally,” and the like.

[0046] Furthermore, the phrase “flowed-material joint” and the like, if used herein, are to be interpreted to include any joint or connection in which a liquid or otherwise flowable material (e.g., a melted metal or combination of melted metals) is deposited or otherwise presented between adjacent component parts and operative to form a fixed and substantially fluid-tight connection therebetween. Examples of processes that can be used to form such a flowed-material joint include, without limitation, welding processes, brazing processes and soldering processes. In such cases, one or more metal materials and/or alloys can be used to form such a flowed-material joint, in addition to any material from the component parts themselves. Another example of a process that can be used to form a flowed-material joint includes applying, depositing or otherwise presenting an adhesive between adjacent component parts that is operative to form a fixed and substantially fluid-tight connection therebetween. In such case, it will be appreciated that any suitable adhesive material or combination of materials can be used, such as one-part and/or two-part epoxies, for example.

[0047] Further still, the term “gas” is used herein to broadly refer to any gaseous or vaporous fluid. Most commonly, air is used as the working medium of gas spring devices, such as those described herein, as well as suspension systems and other components thereof. However, it will be understood that any suitable gaseous fluid could alternately be used.

[0048] It will be recognized that numerous different features and/or components are presented in the embodiments shown and described herein, and that no one embodiment may be specifically shown and described as including all such features and components. As such, it is to be understood that the subject matter of the present disclosure is intended to encompass any and all combinations of the different features and components that are shown and described herein, and, without limitation, that any suitable arrangement of features and components, in any combination, can be used. Thus it is to be distinctly understood claims directed to

any such combination of features and/or components, whether or not specifically embodied herein, are intended to find support in the present disclosure.

[0049] Thus, while the subject matter of the present disclosure has been described with reference to the foregoing embodiments and considerable emphasis has been placed herein on the structures and structural interrelationships between the component parts of the embodiments disclosed, it will be appreciated that other embodiments can be made and that many changes can be made in the embodiments illustrated and described without departing from the principles hereof. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. Accordingly, it is to be distinctly understood that the foregoing descriptive matter is to be interpreted merely as illustrative of the subject matter of the present disclosure and not as a limitation. As such, it is intended that the subject matter of the present disclosure be construed as including all such modifications and alterations.

CLAIMS:

1. A gas spring piston dimensioned to receive an associated flexible wall, said gas spring piston comprising:

a side wall extending peripherally about a longitudinally-extending axis such that an associated rolling lobe of the associated flexible wall can be formed therealong, said side wall at least partially defining a piston storage chamber capable of storing for an extended period of time a quantity of gas having a pressure level greater than an associated ambient atmospheric pressure;

a piston passage extending through said side wall and into fluid communication with said piston storage chamber; and,

a connector fitting secured along said piston passage and dimensioned to receive an associated gas transfer line for transferring pressurized gas into and out of said piston storage chamber.

2. A gas spring piston according to claim 1, wherein said side wall is an outer side wall, and said gas spring piston further comprises:

an inner side wall disposed radially-inwardly of said outer side wall and at least partially defining said piston storage chamber.

3. A gas spring piston according to either one of claims 1 and 2, wherein said piston passage is a first piston passage, said connector fitting is a first connector fitting, and said gas spring piston further comprises:

a second piston passage extending through said side wall and into fluid communication with said piston storage chamber; and,

a second connector fitting secured along said second piston passage and dimensioned to receive an associated gas transfer line for transferring pressurized gas into and out of said piston storage chamber.

4. A gas spring piston according to any one of claims 1-3, wherein said side wall extends longitudinally between opposing first and second ends with the associated flexible wall received along said first end, said gas spring piston further comprising:

a base wall disposed transverse to said longitudinal axis and in spaced relation to said first end in a direction toward said second end, said base wall at least partially defining a mounting plane of said gas spring piston with at least a portion of said piston storage chamber extending longitudinally beyond said mounting plane.

5. A gas spring piston according to any one of claims 1-4, wherein said side wall is an outer side wall, and said gas spring piston further comprises a first inboard side wall extending laterally along one side of said longitudinal axis and a second inboard side wall extending along an opposing side of said longitudinal axis in spaced relation to said first inboard side wall such that a channel is at least partially defined therebetween, said first and second inboard side walls at least partially defining said piston storage chamber.

6. A gas spring piston according to any one of claims 1-5 further comprising a first outboard side wall extending laterally along one side of said longitudinal axis in approximate alignment with said first inboard side wall, and a second outboard side wall extending along an opposing side of said longitudinal axis in spaced relation to said first outboard side wall and in approximate alignment with said second inboard side wall, said first and second outboard side walls at least partially defining said piston storage chamber.

7. A gas spring piston according to any one of claims 1-6, wherein said piston passage extends through one of said first and second outboard side walls and into fluid communication with said piston storage chamber, and said connector fitting is secured along said piston passage in abutting engagement with said one of said first and second outboard side walls.

8. A gas spring piston according to any one of claims 1-7, wherein said first inboard and first outboard side walls at least partially define a first portion of said piston storage chamber disposed longitudinally beyond said base wall in a direction toward said second end, and said second inboard and second outboard side walls at

least partially define a second portion of said piston storage chamber disposed longitudinally beyond said base wall in a direction toward said second end.

9. A gas spring assembly dimensioned for receivingly engaging an associated structural component, said gas spring assembly comprising:

a flexible wall having a longitudinal axis and extending peripherally about said longitudinal axis between a first end and a second end space longitudinally from said first end;

an end member secured across said first end such that a substantially fluid-tight seal is formed therebetween; and,

a gas spring piston according to any one of claims 1-8 operatively connected to said second end of said flexible wall such that a spring chamber is at least partially defined by said flexible wall between said end member and said gas spring piston with said spring chamber being fluidically isolated from said piston storage chamber by said gas spring piston.

10. A gas spring assembly according to claim 9, wherein said end member includes an end member passage in communication with said spring chamber such that pressurized gas can be transferred between said spring chamber and said piston storage chamber by way of said piston passage and said end member passage.

11. A suspension system comprising:

a pressurized gas source;

a control device selectively operable in a plurality of flow control conditions; and,

at least one gas spring assembly according to either one of claims 9 and 10;

said control device fluidically connected between said pressurized gas source and said at least one gas spring assembly such that:

in a first flow control condition, said pressurized gas source and said spring chamber of said at least one gas spring assembly are disposed in fluid communication with one another; and,

in a second flow control condition, said pressurized gas source is fluidically isolated from said spring chamber with said spring chamber and said piston storage chamber disposed in fluid communication with one another such that pressurized gas can be transferred between said spring chamber and said piston storage device.

12. A suspension system according to claim 11, wherein:

in said second flow condition pressurized gas is transferred from said spring chamber into said piston storage chamber; and,

in a third flow control condition, said pressurized gas source, said spring chamber and said piston storage chamber are disposed in fluid communication with one another such that pressurized gas can be transferred from said pressurized gas source and said piston storage chamber into said spring chamber.

13. A suspension system according to either one of claims 11 and 12, wherein said control device is a first control device in fluid communication with said piston storage chamber, and said suspension system further comprises:

a second control device in fluid communication with said piston storage chamber;

said first and second control devices being cooperatively configured to switch between at least said first and second flow control conditions.

14. A suspension system according to any one of claims 11-13 further comprising:

a control system in operative communication with said control device and configured to selectively actuate said control device between at least two of said first, second and third flow control conditions.

15. A suspension system according to any one of claims 11-14, wherein said at least one gas spring assembly includes a plurality of gas spring assemblies, said control device is one of a plurality of control devices with each control device operatively associated with one of said plurality of gas spring assemblies, said pressurized gas source includes a compressor operatively to generate a quantity of gas at a pressure level greater than the associated ambient atmospheric pressure, and said suspension system further comprises a valve assembly operatively connected between said compressor and said plurality of control devices.

16. A suspension system according to claim 15 further comprising a storage reservoir in fluid communication with said valve assembly and operative to store a quantity of gas at a pressure level greater than the associated ambient atmospheric pressure.

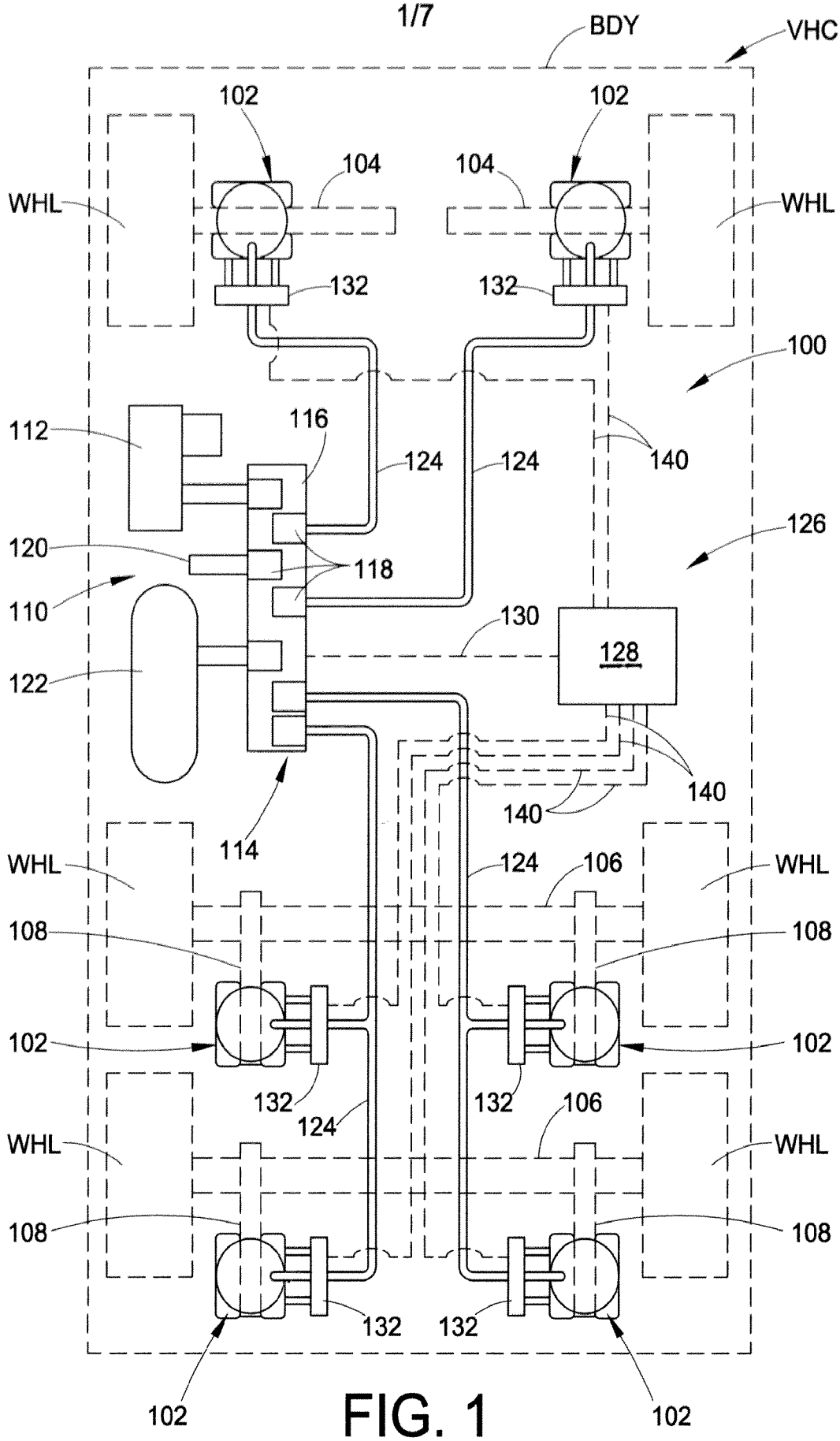

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FIG. 1

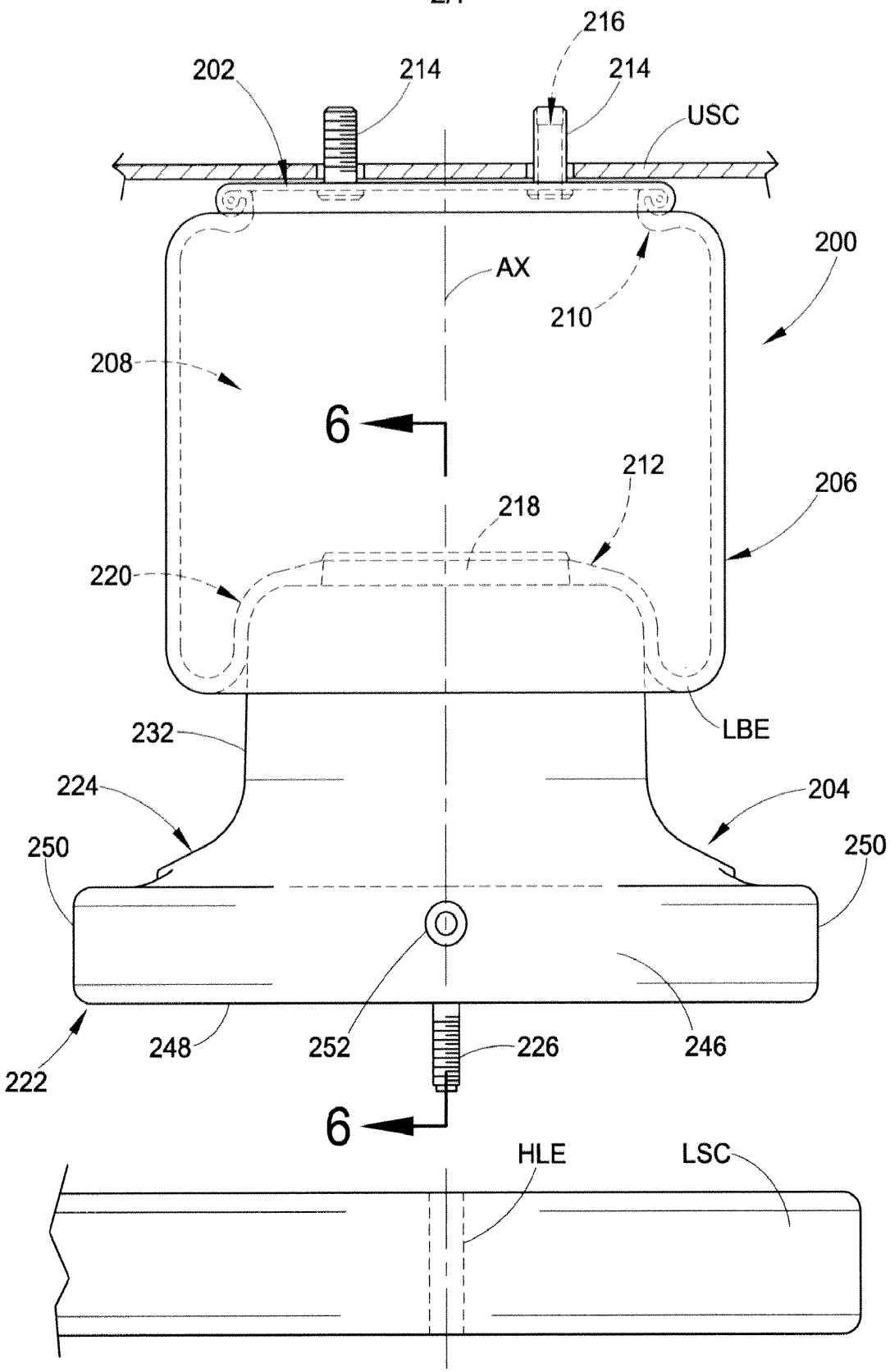

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FIG. 2

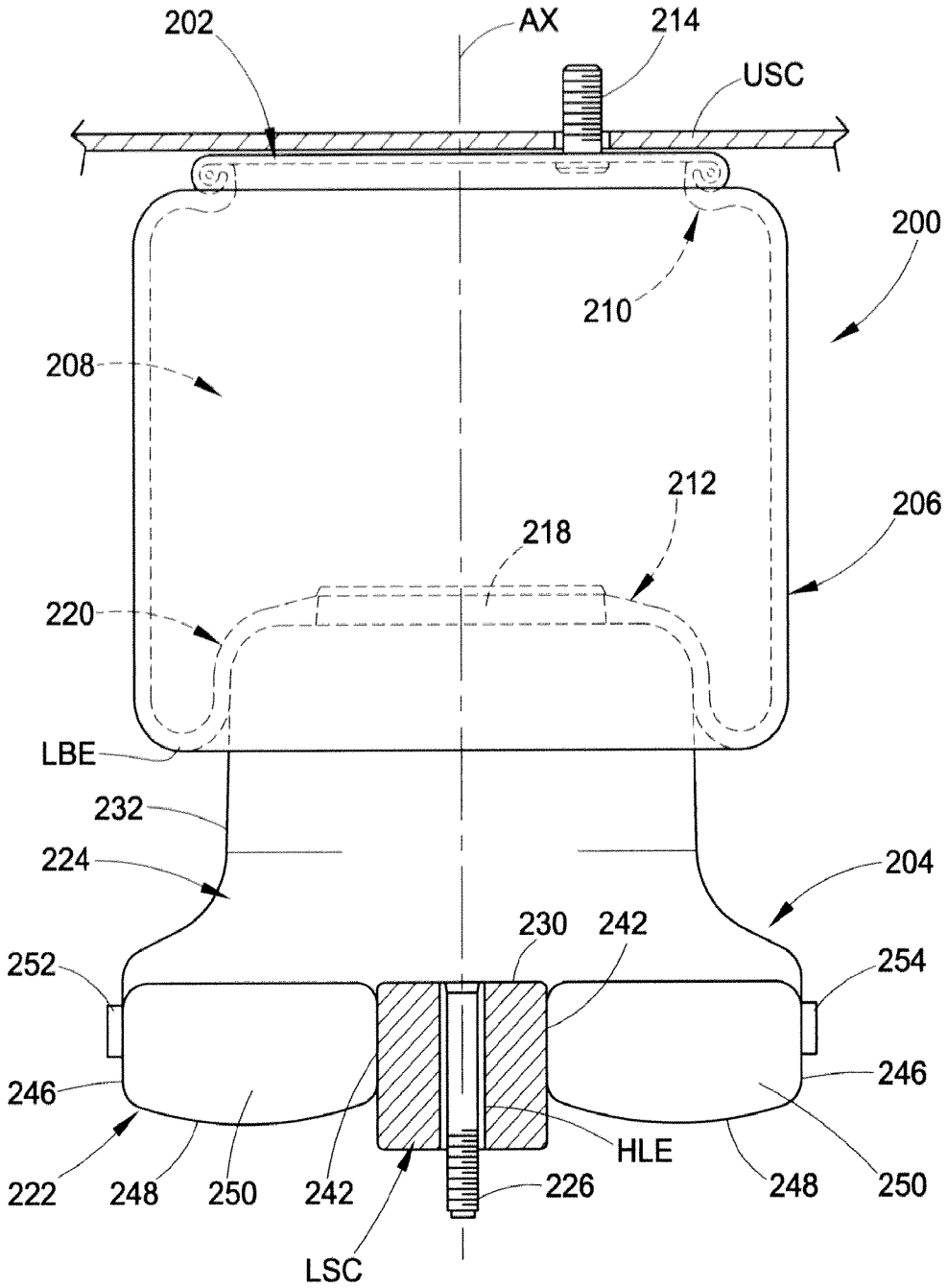

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FIG. 3

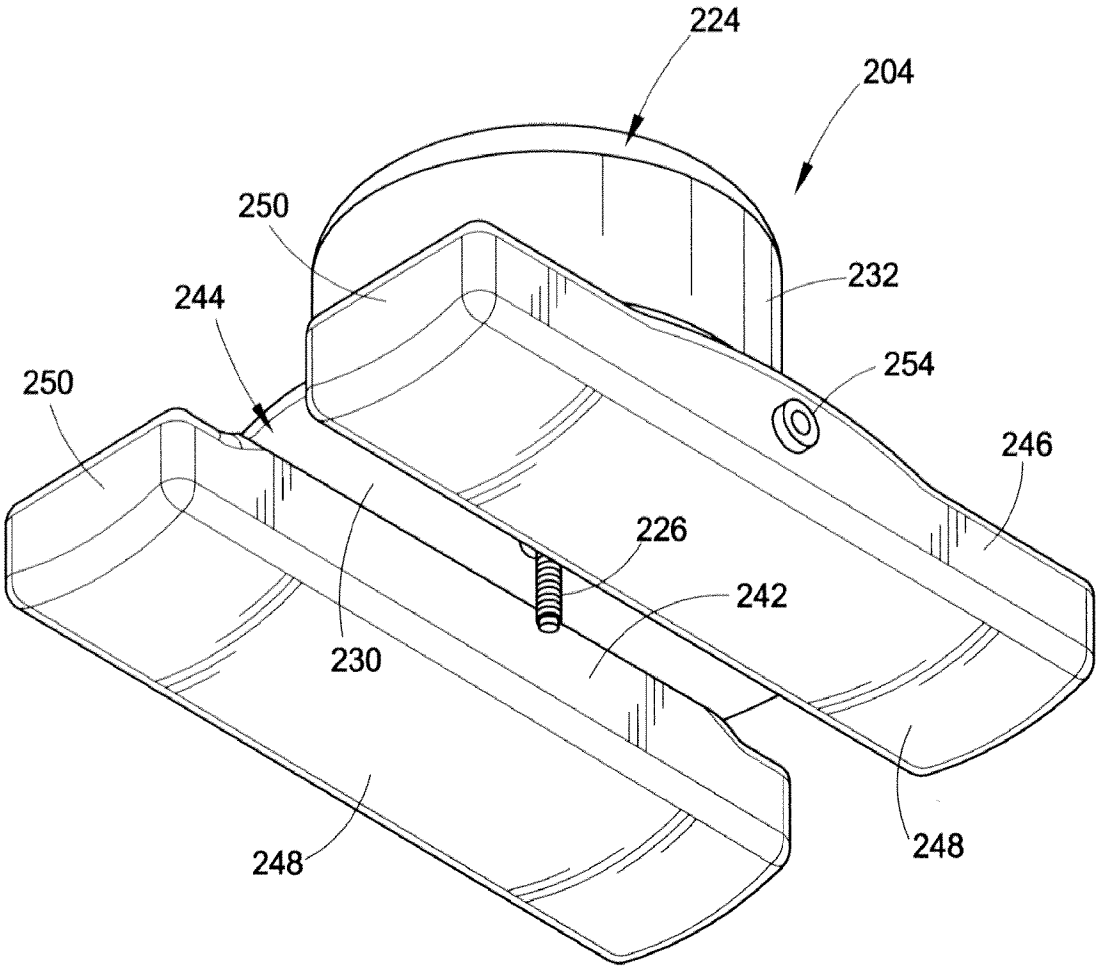


FIG. 4

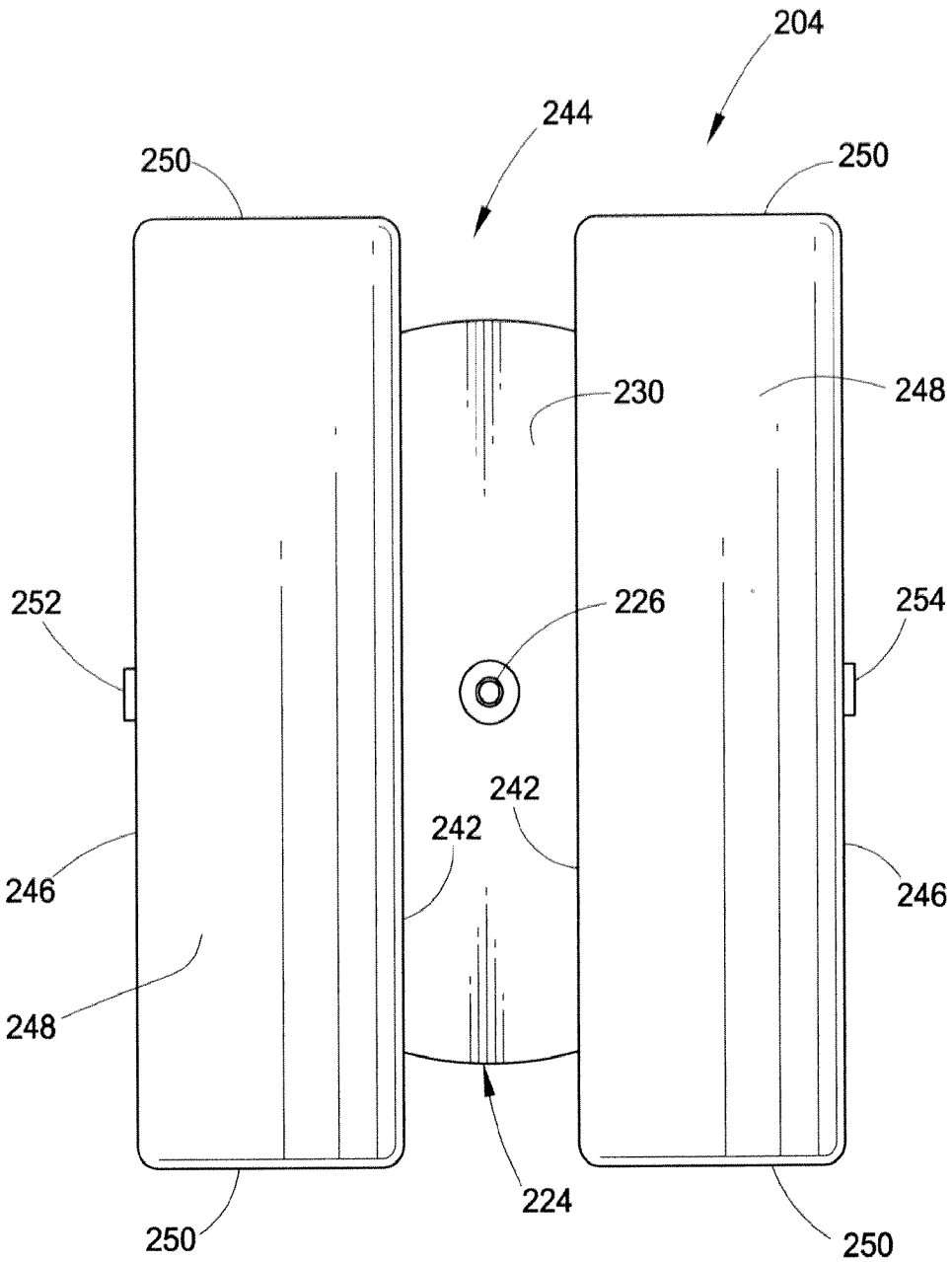

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FIG. 5

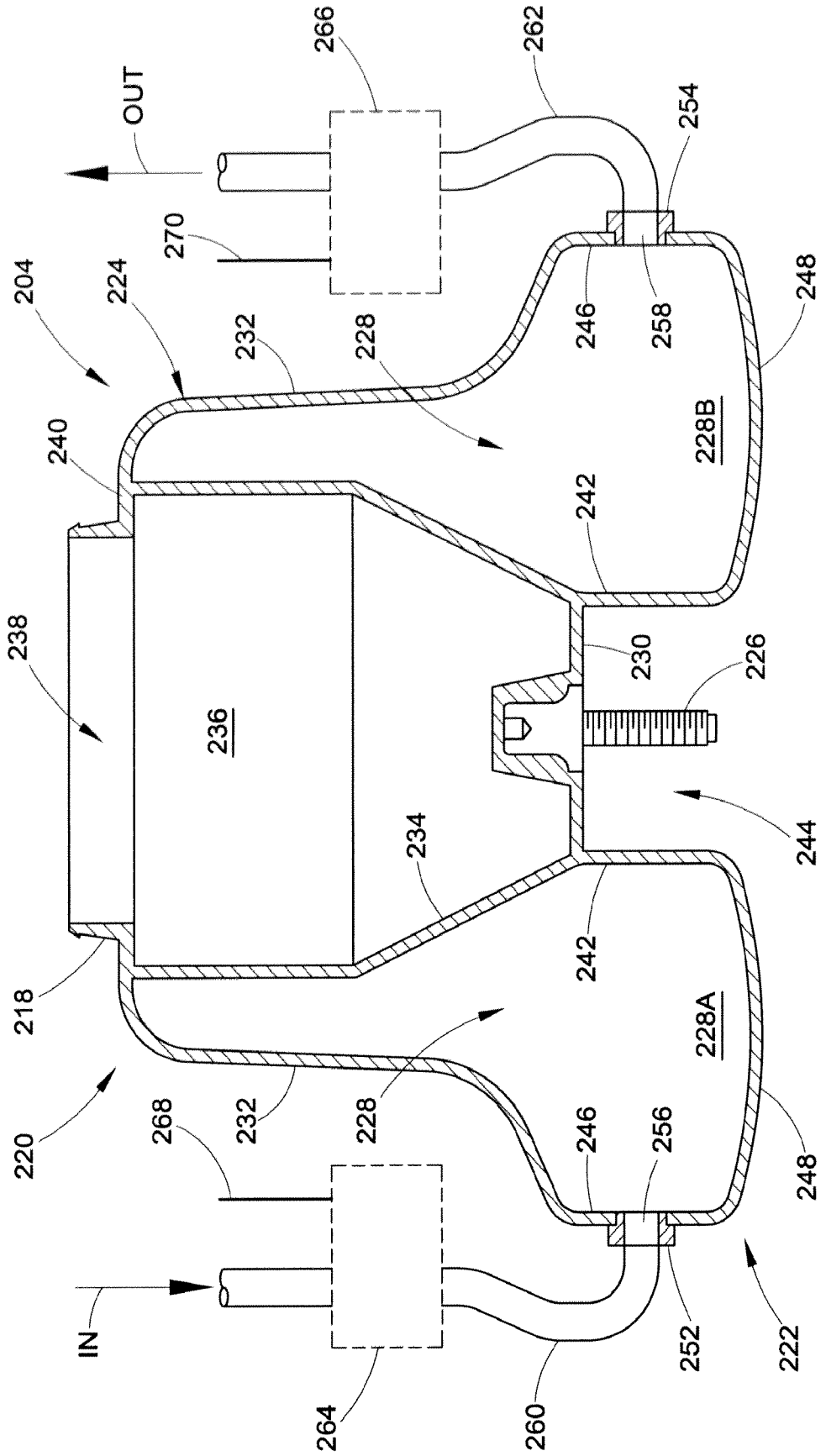

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FIG. 6

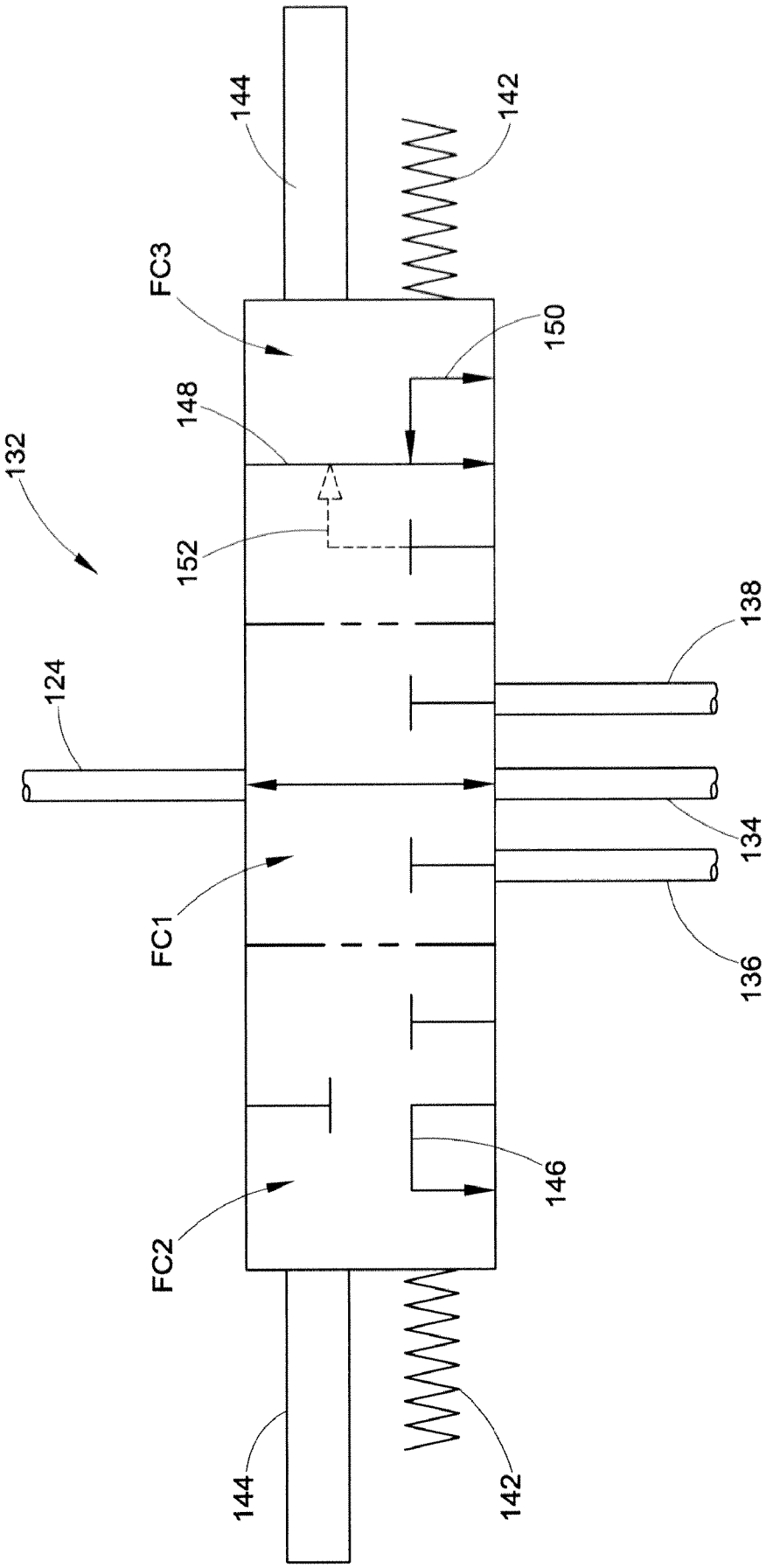


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/021779

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60G11/30 B60G11/27 F16F9/05 F16F9/43
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60G F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 58 199209 A (NIPPON AIR BRAKE CO) 19 November 1983 (1983-11-19) abstract; figure 2	1-16
Y	US 5 413 316 A (EASTER MARK R [US]) 9 May 1995 (1995-05-09) figures 1-4	1-16
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 April 2012	02/05/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cavallo, Frédéric

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/021779

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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